Idaho Completion Project

Bechtel BWXT Idaho, LLC

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Utilizing Divers In Support Of Spent Fuel Basin Closure Subproject

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THE CHALLENGE

A number of nuclear facilities in the world are aging and with this comes the fact that we have to either keep repairing them or decommission them. At the Department of Energy Idaho Site (DOE-ID) there are a number of facilities that are being decommissioned, but the facilities that pose the highest risk to the large aquifer that flows under the site are given highest priorities. Aging spent nuclear fuel pools at DOE-ID are among the facilities that pose the highest risk, therefore four pools were targeted for decommissioning in Fiscal Year 2004.

To accomplish this task the Idaho Completion Project (ICP) of Bechtel BWXT Idaho, LLC, put together an integrated Basin Closure Subproject team. The team was assigned a goal to look beyond traditional practices at the Idaho National Engineering and Environmental Laboratory (INEEL) to find ways to get the basin closure work done safer and more efficiently.

The Idaho Completion Project (ICP) was faced with a major challenge – cleaning and preparing aging spent nuclear fuel basins for closure by removing sludge and debris, as necessary, and removing water to eliminate a potential risk to the Snake River Plain Aquifer.

The project included cleaning and removing water from the following four basins:

- The Test Area North (TAN) 607 basin, built of epoxy-coated concrete, is the largest of the four at 770,000 gallons. It includes an underwater transfer cart connecting the fuel storage pool with a vestibule within the TAN hot shop. Until 2001, the TAN basin was used to store fuel and core debris from the Three-Mile Island reactor.

- The stainless steel-lined, 118,000-gallon Materials Test Reactor (MTR) canal at the Test Reactor Area (TRA) was used to support reactor operations and store spent nuclear fuel.

- The 25,000-gallon, carbon steel-lined Power Burst Facility (PBF) reactor canal was used to support reactor operations and store spent fuel.

- The 11,500-gallon unlined concrete CPP-603 basin overflow pit is an isolated portion of the CPP-603 spent fuel basins at the Idaho Nuclear Technology and Engineering Center. The basins were used to store fuel waiting to be reprocessed to recover usable uranium.

Two of the main challenges to a project like this is the risk of contamination from the basin walls and floors becoming airborne as the water is removed and keeping personnel exposures ALARA.

ICP's baseline plan had workers standing at the edges of the basins and on rafts or bridge cranes and then using long-handled tools to manually scrub the walls of basin surfaces. This plan had significant risk of skin contamination events, workers falling into the water, or workers sustaining injuries from the awkward working position. Analysis of the safety and radiation dose risks presented by this approach drove the team to look for smarter ways to get the work done.

IMPROVING ON THE BASELINE PLAN

The Integrated Basin Closure staff researched methods used both within the DOE complex and in the commercial nuclear industry to determine how basin cleanups were accomplished. The information gathered showed that the base line approach for basin cleanups have been accomplished using traditional methods of scrubbing walls and applying fixative from the walkway or platform surfaces. The cost and safety risks associated with the baseline approach were unacceptable.

The commercial nuclear power industry routinely uses divers to perform many types of plant maintenance and operations, including removing sludge and debris, repairing underwater coatings, and welding. After evaluating many different options, the Integrated Basin Closure Subproject staff concluded that using commercial divers to perform the work was more efficient and safer, than the baseline plan and drastically reduced or eliminated many risks associated with the work.

The overall cost of the project was $1.6 million, versus a baseline estimate of $1.9 million, for a savings of $300,000, and the divers were able to clean the pools and apply the fixative in less time than planned. This cost estimate included cleaning of the basin, and removal of the basin water, debris, and sludge.

The Integrated Basin Closure Subproject marks the first time that a project of this magnitude (removal of sludge and debris, clean and apply a fixative coating to basin surfaces, and drain several basins) has been undertaken.

Overcoming Skepticism

In order to gain the necessary approvals to begin diver activities, it was necessary to educate management and facility personnel on research into nuclear diving practices. The idea of using divers was initially met with great skepticism not only at many facility areas but also by upper level management. Company level and facility level managers and operation teams were shown the many benefits of the approach: individual and total doses would be lower, sludge would be removed, debris would be efficiently removed, the potential for worker injuries would be lower, and the risk of airborne contamination would be drastically reduced. Once the benefits of the diver approach were widely understood and demonstrated, skepticism was gone, and the project received widespread support.

Safety

The use of divers to remove debris and sludge, and apply a coating to underwater basin surfaces eliminated a number of industrial safety risks. The baseline case predicted numerous repetitive-stress injuries that would have resulted from the awkward working positions. The baseline case also had many tasks where there was a likelihood of a worker falling into the water.

Once the Diving Company was on site an equipment inspection was performed and a number of issues were identified that the dive company quickly resolved. The major issues identified were:

- The filtration pump is not designed to be submerged in water when personnel are in the water.
- The operation of the filtration pump required a personnel protective Ground Fault Circuit Interrupter.
- Airline hoses did not have tags certifying the hoses had been pressure tested.

RADIOLOGICAL CONTROLS

In investigating the use of divers to meet the project objective, one finding was met with skepticism at first by many at various facilities – that the divers would have lower doses than workers on the surface.

Before divers arrived at the facility RadCon personnel performed detailed dose rate surveys on basin surfaces. The divers on the dive team were experienced in nuclear diving so they were aware of some of the radiological hazards they were going to encounter. Before beginning dive activities, all areas to be worked were surveyed by the diver himself using remote instrumentation being read by a Radiological Control Technician (RCT). The potential for finding unexpected debris items during cleanup of the basins was anticipated. The dive master was in constant voice and video contact with the divers during dive operations. Divers were instructed not to pick up anything before scanning it. There were no instances in which a diver entered an unsurveyed area or picked up objects that had not been surveyed.

The dive master keeps watch during a dive in the Power Burst Facility canal.

Dose savings using diver approach vs. baseline case

Combined with a real-time remote dosimetry system, the thick neoprene dive suits, and the outstanding shielding properties of the water itself, the total dose for the divers was very low. For example, the highest dose for a diver during the entire basin cleanup project was 453 millirem (mrem), far below the individual exposure anticipated in the baseline case for a 'dry' worker scrubbing walls as the water level dropped.

	TAN-607	MTR-603	PBF-620	CPP-603 Overflow Pit	Total Dose (person-rem)
Estimated Dose Rate for Baseline Case (person-rem) *	2.562	1.356	3.480	5.200	12.598
Actual total dose received by divers (person-rem)	0.824	0.522	0.234	1.739	3.319
Estimated savings in dose vs. baseline case (person-rem)	**1.738**	**0.834**	**3.246**	**3.461**	**9.279**

*Conservatively assumes 0.75 mR/hr for TAN, MTR, PBF and 20 mR/hr for CPP

Contamination Control

Dive suits were reused and exterior surface of the suit became contaminated after the first dive. Controlling contamination on the dive suit and in the dive suit donning/doffing area was critical. It is imperative that the inside of the suit does not become contaminated so an aggressive contamination survey program along with good contamination control practices and house keeping is vital.

Contamination surveys are performed on anything exiting the water, suit drying area, and inside the donning and doffing area. The diving suit includes a helmet, imbecile line, gloves, and a dry suit. It is very important the dive suits are donned and doffed in the same manor each time. Removable contamination surveys of the neck ring and the zipper (interior of the dive suit) before donning the suit verified that the suits were not internally contaminated. When it came time to doff the suits contamination surveys were conducted and the divers were instructed to wait for the two tenders to remove the helmet and the diver was to duck out from under the helmet. The area of concern in this task is where the helmet connects to the diving suit. It must be wiped down and dry before the helmet is removed.

Controlling the amount of contamination in the dive suit donning and doffing area is dependent upon house keeping in the area and how well the dive suits were rinsed off and wiped down. House keeping was critical. With contaminated water dripping off the diver each time they exited the basin, it was essential that absorbent pads be continually changed out. The staging rack for the suits, helmets, and umbilical needed to be wiped down to maintain contamination levels as low as possible. Rinsing off the suits as the divers inter and exit the water is also important. Wetting down the suits prior to entry creates a film thereby hopefully reducing the amount of contamination that will be on the suit when the diver exits. Rinsing down the divers as they exit the water also reduces the amount of contamination that is tracked into the dive suit donning/doffing area.

Critical to preventing the likelihood of a skin contamination event or an internal deposition is the sequence of donning and doffing the diving suit. The diving subcontractor had a sequence for donning and doffing the dive suit that was well-defined. The divers and tenders walked through the sequencing with the Radiological Control Personnel and explained the critical areas where contamination events were likely to occur. The dive team completed 411 dives and only had two skin contamination incidences. Even though the contamination presented little to no dose to the divers, the Lesson Learned was the importance of tenders and the diver taking great care during donning and doffing of the dive suits.

Note: The team completed 265 dives before the first skin contamination event occurred, a drop of water reading 3,000 disintegrations per minute (dpm). The contamination was immediately removed. A second skin contamination 4,200 dpm occurred at PBF.

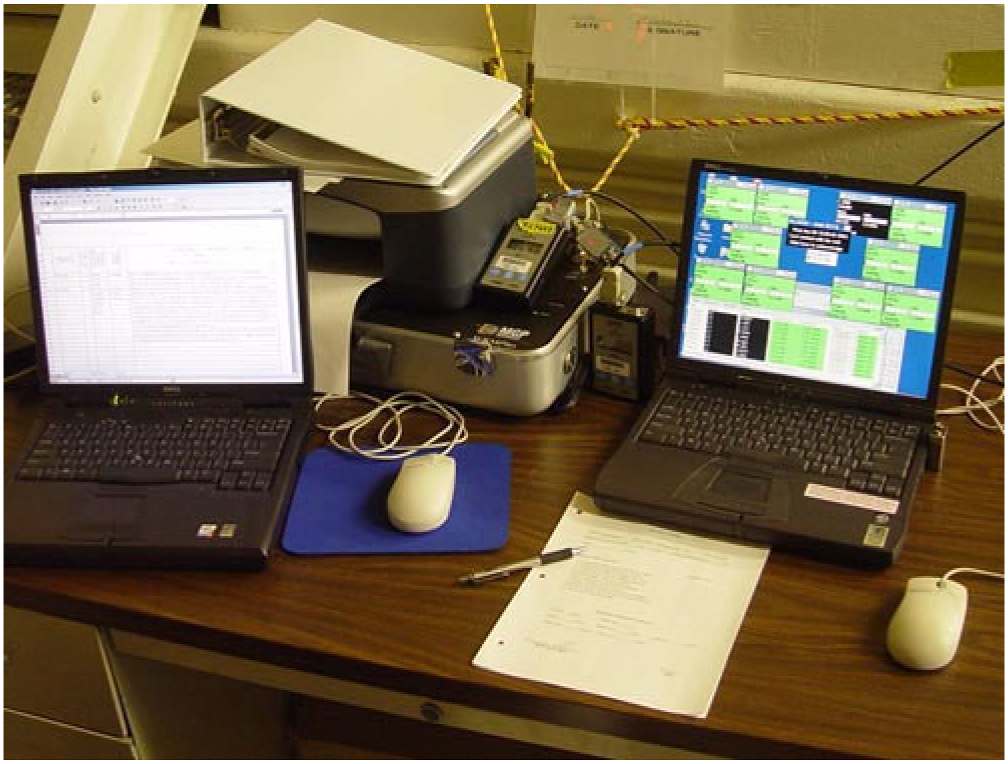
Dive tenders spray a diver as he emerges from the water for contamination control.

After the first dive, a evaluation of the radiological controls was conducted to identify potential operational deficiencies. Several items were identified and implemented to reduce the risk of spreading contamination:

- A splash curtain was installed along the entire length of the tenders' work area.
- Divers were instructed to remain still with arms outstretched while the suit was completely dried.
- Tenders were instructed not to get underneath the diver's arms to avoid dripping water.

Dose and Dose Rate Monitoring

The project used a remote dosimetry system to monitor the divers. This is a standard system that is used in a number of commercial power plants. Each diver was fitted with five dosimeters, one on each limb and one on the torso. The dosimeters transmitted the data real-time to a control point where the RCT's monitored the divers the entire time they were in the water. Constant monitoring of the telemetry system prevented unplanned exposures throughout the dives. Whenever any one of the diver's dosimeters showed an elevated dose rate, they were instructed to survey and either remove or work around the source of radiation. Divers averaged about 6.5 mR per dive (electronic dosimeter results), with two dives a day, well below the dose estimated for the baseline case. In a few instances, contact with the telemetry system was broken. It was determined that correct placement of the antenna on the diver's suit is necessary to maintain communication.



RCTs are able to monitor each diver's dosimeters on the laptop at right.

Prior to diving operations commencing dose rate surveys were conducted in each basin using underwater probes. This information was used each day to provide the divers with anticipated dose rate information before they entered the water. Once in the water each diver would survey the area they planned on working. Survey results were read out by an RCT at the control point and relayed to the diver.

Shallow dose from beta radiation was not an issue because of the neoprene dry suits. The thickness of the suits and the material made for great beta shielding. After the initial application of the epoxy fixative, higher than expected beta dose rates were identified on the knees and toes of the dive suits. Elevated beta dose rates were the result of contamination from the floor becoming stuck in the fixative on the knees or toes of the diver's suits. Once dried, the epoxy was easily removed. In subsequent dives, duct tape was placed on the knees and toes of the suits and was removed with the fixative after divers exited the basins. These practices reduced beta dose rates by 90 percent or more.

Fixative tended to build up on the suits. Removal by hand affected the integrity of the dry suits, which resulted in some suit failures. The subcontractor suggested using plastic suits during fixative application over the dive suits to keep epoxy buildup from affecting the dry suit integrity.

Other RADCON Lessons Learned:

- Make sure enough instrumentation spare parts are on hand to eliminate delays (e.g., multi-plexers, antennas, and dosimeters).

- Underwater AMP-100 radiation detectors performed flawlessly throughout the job. The small probe size makes them ideal for surveying corners, cracks, and other hard-to-reach spaces in the basins. They are also compatible with the telemetry monitoring system. Further refinement of the interface with the Winworm telemetry software improved the interface even further.
- Beta dose estimates should be set by the radiological engineering group using expected isotopes, the attenuation factor of the dive suits, and the protective clothing that will be worn prior to completing the radioactive work permit (RWP) for each basin job.
- A supply coordinator should ensure enough supplies are on hand to avoid the need to scavenge from other departments (e.g., towels, personal protective equipment, absorbents, rad and non-rad bags).
- Smears of the diver's suits and airlines were initially between 20,000 and 40,000 dpm/100cm^2 (beta-gamma), but the contamination levels declined rapidly as the pools were filtered and remained at 2,000 to 6,000 dpm/100cm^2 on dive gear and 2,000 to 8,000 dpm/100cm^2 on the floor and stairs of the diver's work area. These levels are well below the action level of 50,000 dpm/100cm^2 specified in the RWP.

OPERATIONS

Calcium Hypochlorite

Applying calcium hypochlorite to maintain the water quality to the water in the TAN basin produced an unanticipated side effect – it turned the water a dark brown color. The color change was due to chlorine in the additive causing metals in the water to precipitate out. Although it didn't hamper the work significantly, the sudden color change was a dramatic difference from the nearly crystal-clear appearance of the basin water after sludge removal was completed.

One-team Approach

The one-team approach helped to ensure smooth operations from start to finish during the basin cleanup activities. With similar work scope at four different INEEL facilities, the one-team approach was the most efficient way to get the work done and ensure that Lessons Learned at one basin are applied to the others, much the same way ICP has realized efficiencies with crosscutting D&D and Voluntary Consent Order service teams.

In the baseline case, each facility would have been responsible for its own basin, with its own teams. The individual facility requirements vary, and an opportunity to realize efficiencies would be lost. It would have been much more difficult to apply Lessons Learned at each of the other facility basins, resulting in more cost, more time, and more exposure for ICP workers.

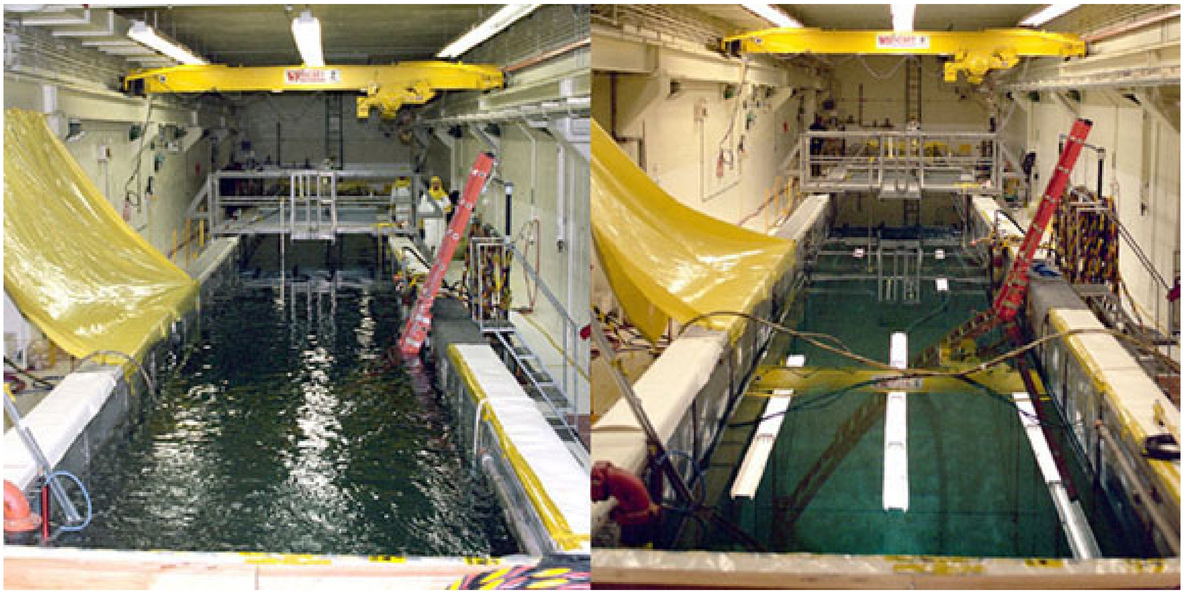
Additionally, the Scope of Work for the project was issued with performance specifications, leaving how the actual field work was done to the subcontractor. BBWI adopted a 'teaming' approach with the subcontractor that fostered open communication and a 'can-do' attitude.

Debris Removal

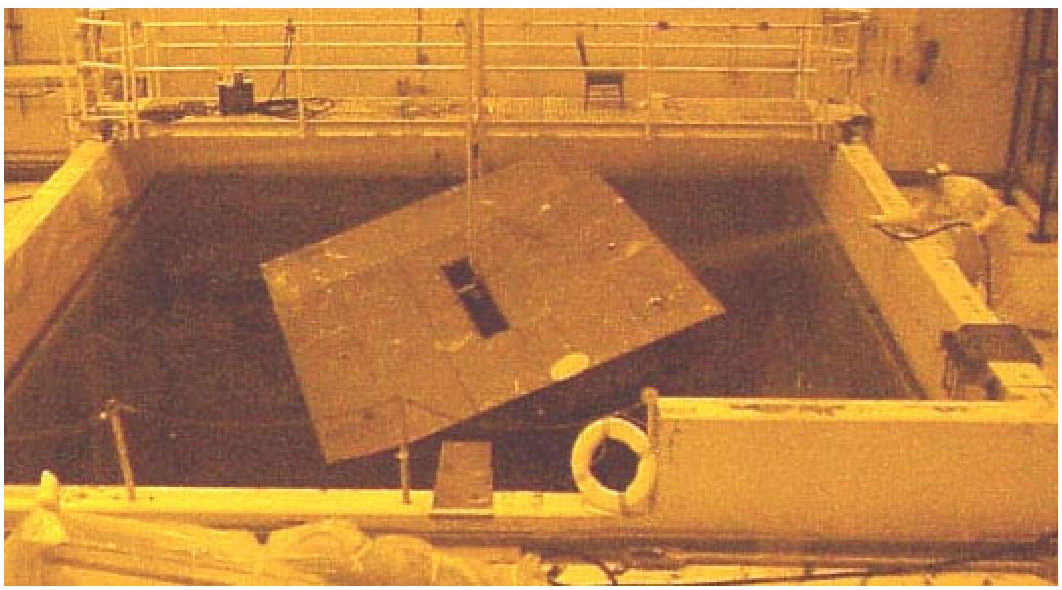
The project began with the assumption that the majority of debris in the basins would already be removed, but it didn't take long to realize that much of that debris removal work could be completed more efficiently if the divers assisted facility operation's personnel. In addition to decontaminating and applying fixative to the basin surfaces, the divers helped TAN personnel remove nearly 31,000 pounds of service equipment and other spent fuel-handling debris.

Diver assistance was a great improvement over the initial plan to remove this equipment as the water level dropped. While this addition to the original diver scope of work resulted in increased subcontract cost and schedule requirements, the net impact was very beneficial to ICP as a whole.

The diver approach to basin cleanup eliminated likely risks associated with the baseline approach for debris removal. The divers were able to locate and deal with tiny but highly radioactive debris particles and native mercury in the TAN basin that likely would never have been spotted before water was removed in the baseline case. In one case, divers located and removed a small screw head reading 90 R per hour. The screw head was placed in a container underwater, with the diver receiving only 5 mR (electronic dosimeter result) during the disposal operation.



The MTR canal before and during cleaning.



The transfer cart is removed from the basin vestibule in the TAN hot shop.

Transporting Water

Water removal, the primary goal for the basin closure project, was easier to accomplish at PBF, MTR and INTEC because they were able to use existing on-site evaporation ponds. However, there are no evaporation ponds at the TAN facility. Thus, after extensive characterization, arrangements were made to transfer the 770,000 gallons of water from the TAN basin to the TRA evaporation pond, approximately 30 miles to the south.

Water was trucked from the TAN basin to the TRA evaporation pond.

Prior to starting shipments the pumping systems on the trailers were contained inside of plexiglass housings to prevent the spread of contaminated water during unloading operations. After TRA management approval, water transfer began on June 2, 2004. Two 6,200-gallon tanker trailers were used to transport the water. Water was removed from the TAN basin by means of a specially-designed pumping system that included a submersible pump, multi-bag filter unit, and integrated flow control instrumentation. Operation of the pump was tied into level sensing instrumentation inside of each trailer and was configured to shut off automatically when the trailer was filled to 90% of capacity by volume. 138 trailer loads were filled in this manner without any incident of water leakage or spread of contamination. Water removal was completed on Sept. 2, 2004.

Fixative Warranty and Application

Applying fixatives for contamination control is used across the nuclear industry, but it wasn't widely known that some fixatives could be applied underwater. More than 100 types of coatings and fixatives were studied to determine which ones would be suitable for the INEEL Basins; 13 fixatives were tested, and the results were summarized in report *INEEL/EXT-04-01672*. A proprietary two-part, underwater epoxy owned by the subcontractor was selected to be applied by their divers after scrubbing off the basin walls and floors and vacuuming up the sludge.

Hull Scrubber

It turned out some expectations about fixative application were not met. The epoxy coating is much more difficult to apply under water than house paint in air. It took considerable effort to get a complete coating that passed the dive master's inspection. The condition of the existing surfaces directly effects the time needed to apply the fixative. At TAN, the divers also had to deal with the bubbled and loose paint layer on the basin walls. The basin walls at INTEC were even more deteriorated than at TAN. The roller was not effective there, so fixative had to be applied by hand. Fixative application at MTR and PBF went smoother with the steel-lined basins.

The project sought and received, from the diving company subcontractor, a three-year warranty on the fixative coating for each basin. The coating is designed to last 10 years, and the warranty includes periodic inspections, with crews returning to reapply fixative as necessary. This minimizes potential future expenses as the final closure status for the basins is determined.

Applying fixative to the wall of the MTR canal.

While applying fixative at TAN, divers found a tiny leak in the basin. The fixative kept disappearing through a three-millimeter crack in the basin wall. Work was temporarily halted while the team patched the leak. The Environmental Protection Agency and state agencies were notified of the leak, and new CERCLA site paperwork is being filed so the site can be properly assessed and dealt with after basin closure. It is highly unlikely that the leak would have been found using the baseline method.

Final basin cleanup

The level of contamination remaining on basin walls after water removal is believed to be affected by the activity level in the water and how long the water was allowed to remain in the basins after fixative application. It seems that the longer the amount of time residual contamination left in the water is in contact with the cured fixative, the higher the contamination levels will be when the water is removed. For comparison, the removable beta-gamma contamination levels on the TAN basin walls read as high as 12,000 dpm/100cm^2. Water removal was not completed until 12 weeks after the divers completed their work. At INTEC, water removal took place almost immediately after the fixative cured, and removable beta-gamma contamination levels were around 1,000 dpm/100cm^2.

After water was removed from the basin at TAN and MTR, a final rinse-down of the walls and floor, as well as using large squeegee tools, helped get as much water out of the basins as possible while keeping contamination spread to a minimum.

Workers rinse down the basin floor at TAN as the last of the water is pumped out of the transfer cart trench.

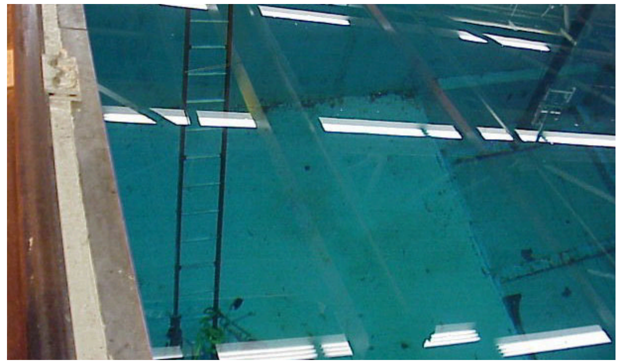
CONCLUSIONS

The approach used by the Integrated Basin Closure subproject is an example of achieving accelerated cleanup goals by working smarter and thinking “outside the box.” It isn’t without its negatives, however. The subproject found that more time and budget should be allocated to allow for management self-assessments before beginning the work and to educate the diver subcontractor on the intricacies of DOE and INEEL safety culture and procedures. Still, the approach improved on standard baseline deactivation methods in several ways:

- Reduced dose to personnel dramatically
- Using divers to remove material & debris and apply a fixative underwater reduced the industrial safety risks to the workers
- Reduced cost
- Reduced schedule
- Allowed for closer inspection of debris, other materials, and basin surfaces
- Reduced the potential for airborne contamination
- Facilitates shared Lessons Learned at other basins.

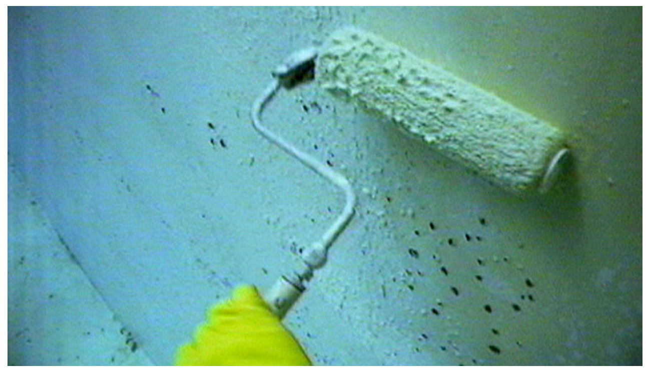
Basin cleanup process, start to finish

Divers enter the basin to begin cleaning



After sludge removal and filtering begins, water clarity improves rapidly

Proper donning and doffing techniques are essential for contamination control

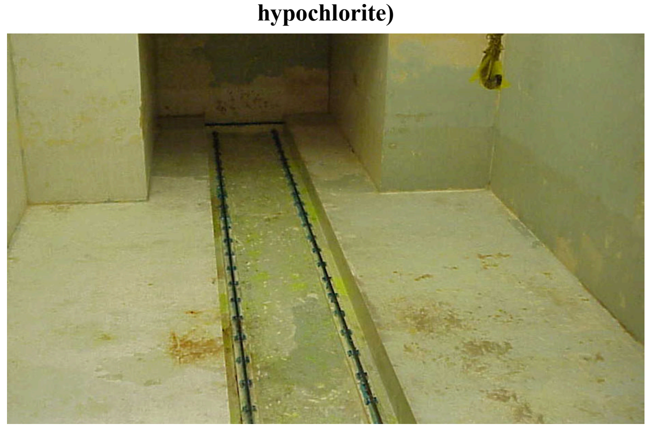


2-part epoxy fixative is applied underwater

Debris and equipment removed from basin

Water removal under way (Water darkened by calcium hypochlorite)

Final rinsedown of basin



Water removal complete

Four INEEL spent fuel basins are shown cleaned, with fixative applied water removed

TAN-607

MTR-603

PBF-620

CPP-603 Overflow Pit